BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Mission Options for a Space Station: Crew Rotation and Mission Types - Case 710

DATE: May 13, 1968

FROM: G.T. Orrok

## ABSTRACT

The influence of several crew rotation regimes on a two year space station, in particular the Saturn V Workshop, is considered. Resupply by quarters with three man CSM's is assumed. Several distinct "mission options" emerge, dependent on the lengths of time individual crew men spend on orbit; these are variously suited to medical (e.g., long times) and to other (shorter times) objectives for the station. An attractive mix is obtained when the on-orbit life of a logistics vehicle is twice the resupply interval, but other implementations give similar results. The work is illustrative, and the crew rotation schemes should not be considered "optimized".

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MEMORANDUM FOR FILE

The Saturn V launched workshop, of 1-1/2 to 2 years life, has several possible "mission options" dependent on crew rotation. The options are distinct on the basis of the time individual astronauts spend in orbit, and thus, inferentially, on the balance of medical (long-duration) versus other (short duration) objectives.

The resupply profiles discussed here are limited to quarterly launches of three man logistics vehicles (AAP CSM). Quiescent orbital lives of 60, 90 plus, and 180 days are considered. The "incremental rule" is followed for astronaut time in space; e.g., durations can be increased only a factor of two. It is assumed that a 56 day mission precedes the two year workshop.

Each of the cases below is described by a figure (1 through 7) in which the abscissa, time, covers a two year period. The time that an individual astronaut spends on station is indicated by a horizontal line.

Case I. Logistics vehicle life less than launch interval (Fig. 1)

This case, while not nominal, is highly distinctive; it is important for other cases in the contingency of premature crew return. Some properties are as follows:

(1) The Workshop has an unmanned mode of operation. Engineering man-hours for de-activation and activation must be allotted. Some automated experiments might be flown; for instance, Earth Applications experiments are advantageous if the Workshop is stored gravity gradient stabilized.

(2) No growth in crew time in space is obtained. Medical experiments would be de-emphasized after sufficient data were obtained. Scientist astronauts other than doctors would fly; a varied scientific program results.

Case II. Logistics Vehicle life just greater than launch interval (Fig. 2) No Crew Transfer

When the logistics vehicle life exceeds the launch interval, overlap is possible. This is the nominal case. In the simplest version, a given crew returns with its own vehicle. The difference between this and case I is:

(1) Elimination of the unmanned mode (except contingency).

(2) Elimination of deactivation and activation operations.

(3) In-flight handover to the new crew. MSC estimates that a minimum time for such handover is four days. As before, crew time in space is not increased, and medical activities are de-emphasized.

Case III. Logistive vehicle life just greater than launch interval: Crew Transfer - Maximized duration (Fig. 3)

A variety of cases arise when crew transfer is permitted. Figure 3 is an obvious extreme, directed at the achievement of maximum duration for man in space under the constraints that successive durations are doubled.

It is assumed (a) at the start of the program that 120 days duration (somewhat more than 2 x 56 days) is permissible, and (b) that the post flight evaluation of a 90 day crew will take 30 days and qualify durations of somewhat more than 180 days ($\sim$210).

In Figure 3, crew man A is returned to Earth at 90 days. Following analysis, the remaining crew men are either recalled at 120 days or given a go for 180 days duration. Subsequently, crew man B is returned at about 200 days and another man at a year. Their replacements remain in orbit for the Workshop life.

Some properties of Case III are as follows:

(1) In a two year flight, durations of 90 days, 180 days, 360 days (2 man), 540 days, and 630 days are achieved.

(2) Heavy emphasis on medical monitoring is required; the qualification of man for long duration flight is the primary objective.

(3) Most logistics crew men fly only for the overlap interval which is brief as long as "90 days" logistics vehicles are launched on quarters.

The medical statistics of Figure 3 are poor, and would be improved by doubling crew size. A simple minded doubling (6 man space craft serviced by 6 man logistics) may be considered part of Case III.*

Figure 4 shows a case, with three man crew, in which improved medical statistics are obtained at the expense of duration. In two years, the durations achieved are 90 days (6), 180 days (3), and 360 days (3).

Twelve men fly only for the overlap interval.

Case IV. Extended overlap

The number of man hours in space available for other than medical purposes is affected drastically by the amount of overlap. Some reasonable period must be allotted for accommodation to the Workshop environment, for instance, five days. Considering this, a month seems a reasonable minimum tour of duty for a specialized science astronaut. A distinct case, then, probably exists for overlaps approaching 30 days and more (logistics vehicles of 120 days life or more). It is characterized by a mix of long duration and short duration crew men.

In Figure 5, an example employing 180 day QCSM's is shown. Early flights are held to durations close to 90 and 180 days until two crew men at each duration have been examined on the ground. In the later flights, the crew complement is six - two, possibly scientists, on short tours of duty ($\sim$ 90 days) and four, medical subjects and engineers, on long duty (up to a year in this example).

Very similar Workshop manning can be obtained in other ways. Two examples of this are given. In Figure 6, a two year "escape" or "return" vehicle is launched with the Workshop and a 3 man crew. Logistics is by 90 day CSM. The first CSM launch follows the Workshop by a short interval to permit return of 2 crew members at 90-100 days. The escape vehicle is conceptually a CSM.

If the 2 year vehicle is "new", a 6 man, 2 year escape vehicle can be used with 14 day CSM's to make a very attractive program of this nature (Figure 7). The double overlap, leading to temporary 9 man operation of the Workshop is optional for Figure 6 but compulsory for Figure 7.

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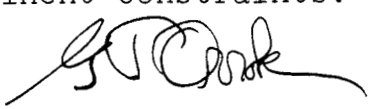
*12 men on orbit during overlap period.

Summary

Considered as a function of crew times in orbit, mission profiles for the Saturn Five Workshop fall in two distinct classes, the discrete case in which all crew men fly for a single duration (60-90 days) and the long duration case where steady increase of crew time in orbit permits some crew members to fly for a year or more. The two cases correspond to general science (e.g., men operating well within their known limitation) and to a medical prime case (men who may be near the edge of human performance in space and who must be closely monitored.)

Other significant cases are shown: the case when the Workshop is regularly left unmanned is an important subcase of the discrete profile; the "long duration" cases are readily converted into mixed crew cases in which both classes of activity may be pursued. No representation is made that the particular profiles shown are optimized, or that their construction reflects all pertinent constraints.



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G. T. Orrok

Attachment
Figures 1-7

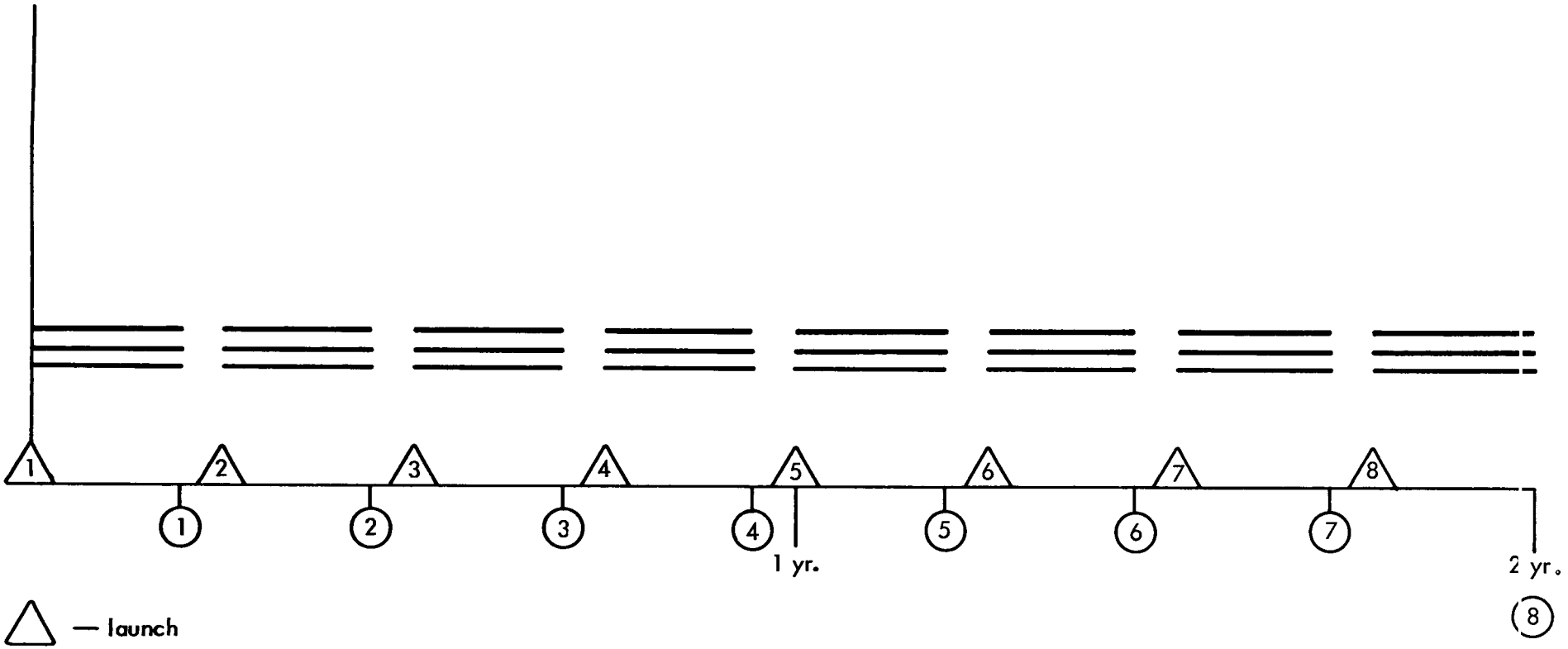



Figure 1. Men in orbit versus time. Each bar represents a single crew man
Case 1, 3 man CSM, 56 days.

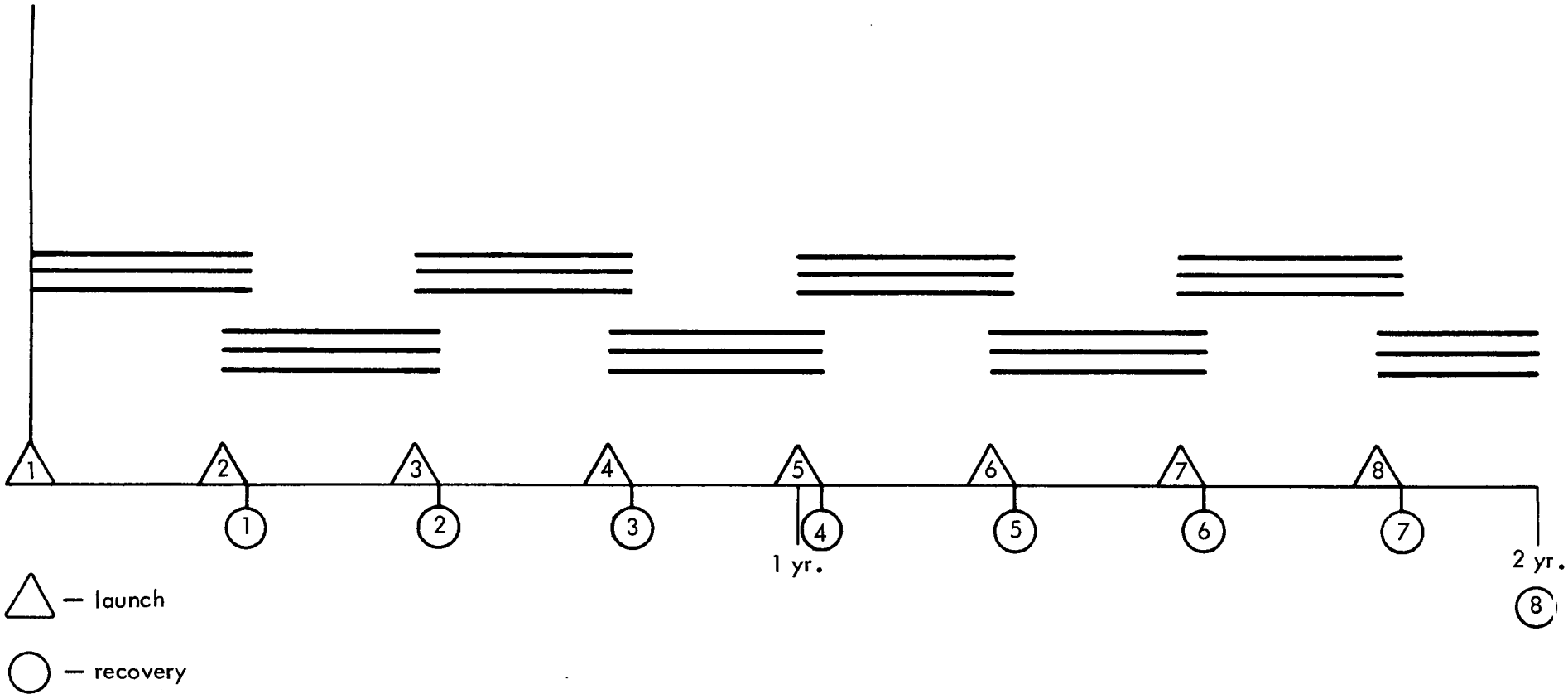



Figure 2 Men in orbit Versus Time. Each bar represents a single crewman.
Case II, 3 man CSM, 90 plus days

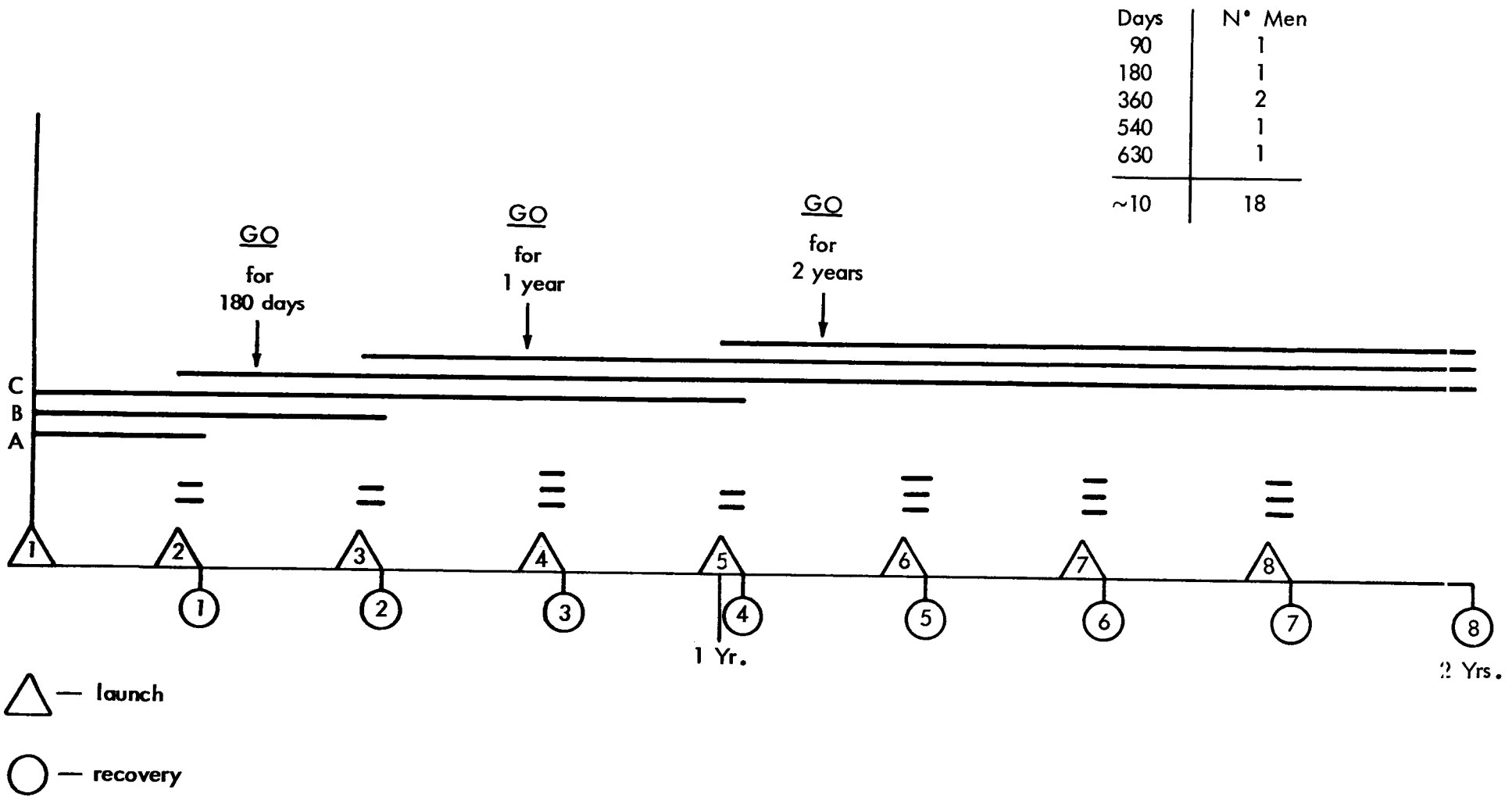



Figure 3. Men in orbit versus time: Case III, 90+day 3 men CSM, with crew exchange to obtain maximum duration. GO/NO GO decision for doubled duration available 30 days post-flight.

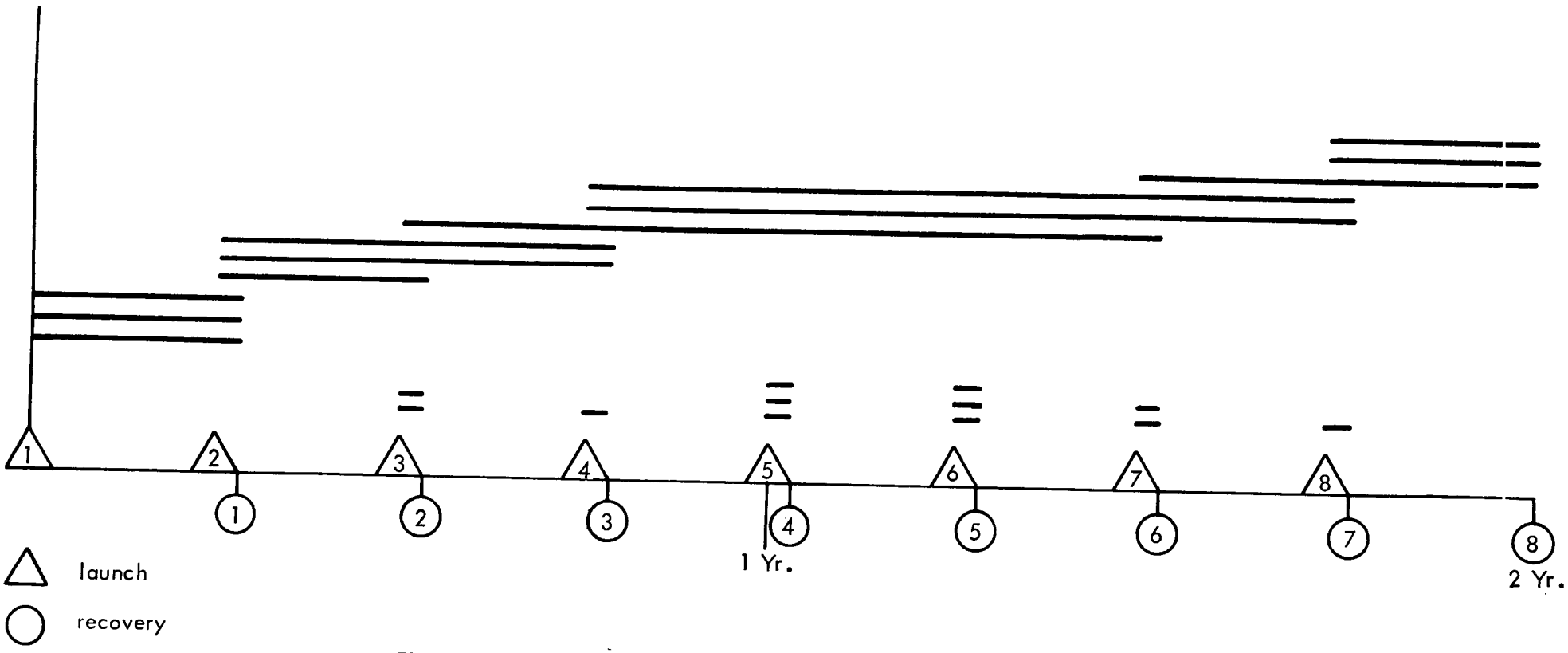
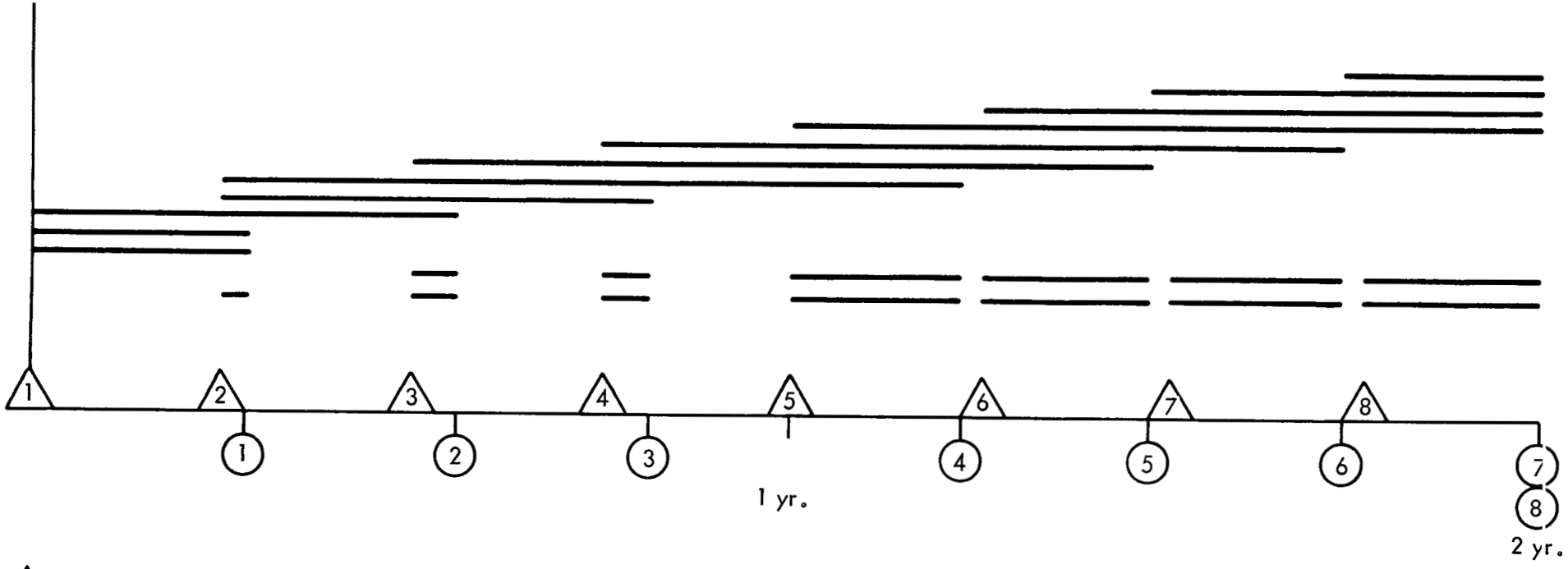



Figure 4. Men in orbit versus time: Case III, 3 man 90+day CSM, improved medical statistics.

| Days | N° Men |
|---|---|
| 90 | 6 |
| 180 | 3 |
| 360 | 3 |
| ~10 | 12 |




launch

recovery

Figure 5. Men in orbit versus time. Case IV, 3 man 180 day CSM, Extended overlap.

| Days | N° Men |
|---|---|
| <45 | 5 |
| ~90 | 11 |
| 200 | 33 |
| ~360 | 4 |

| Days | N° Men |
|---|---|
| 90 | 15 |
| 200 | 3 |
| 270 | 1 |
| 1 year | 5 |

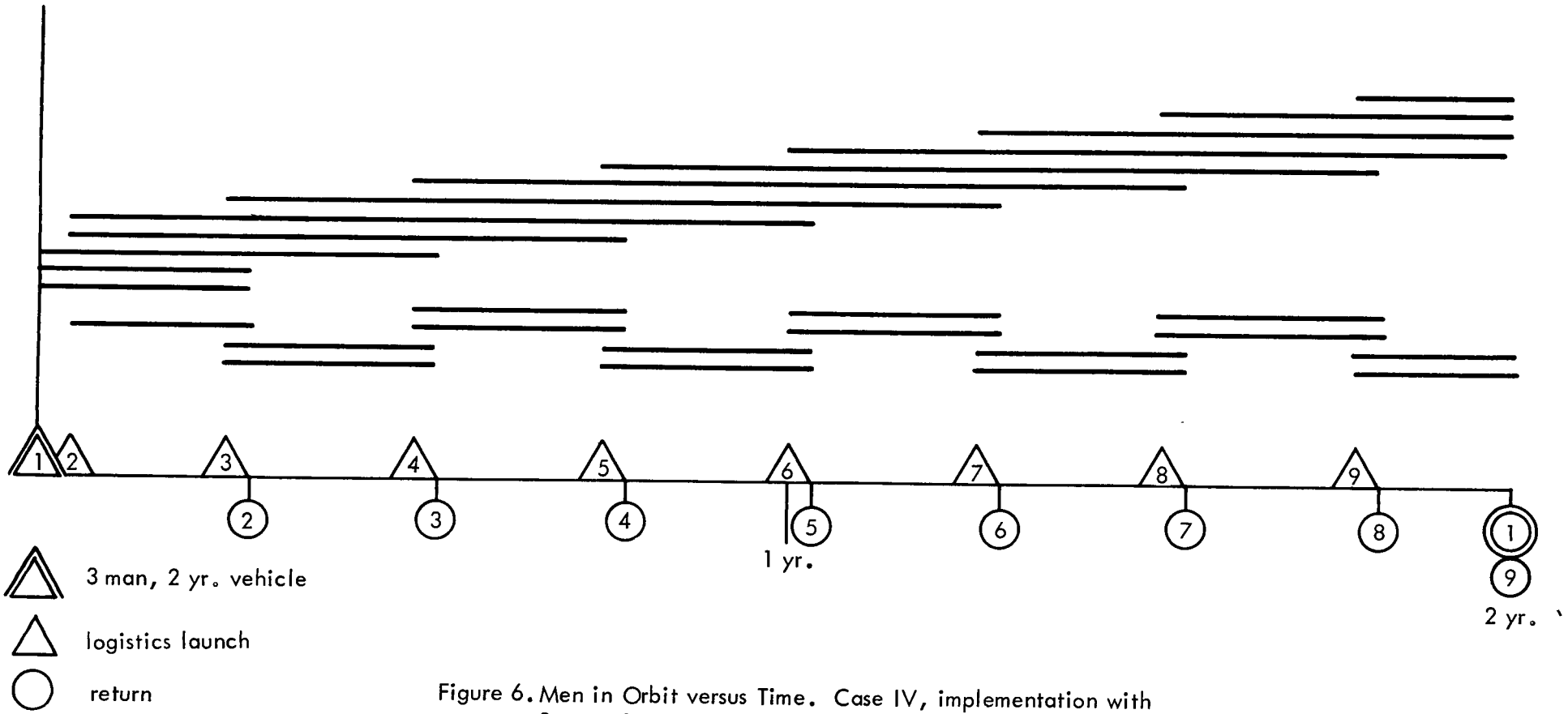



Figure 6. Men in Orbit versus Time. Case IV, implementation with 3 man, 2 yr. "escape vehicle" , 90 day CSM.

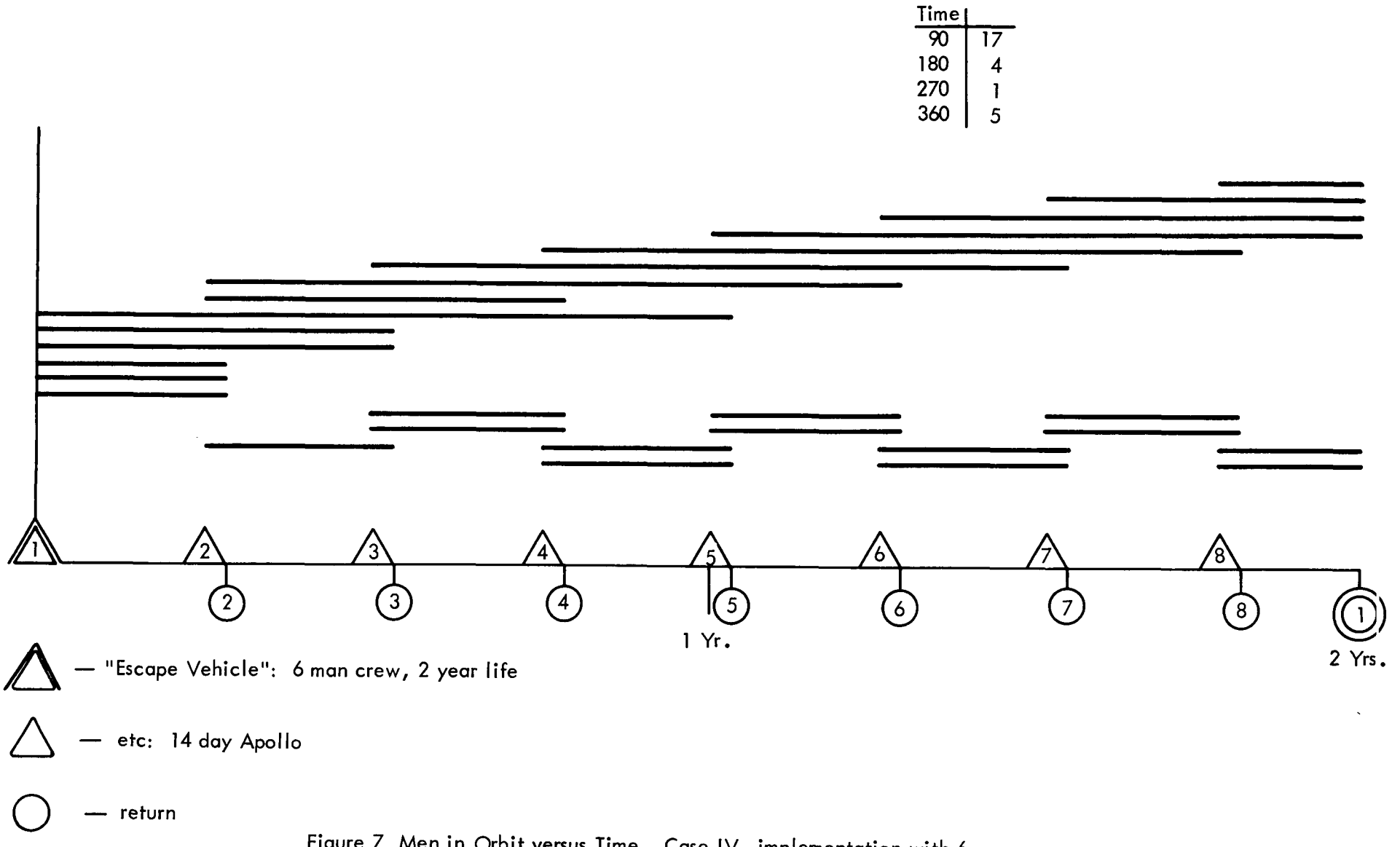



Figure 7 Men in Orbit versus Time. Case IV, implementation with 6 man, 2 year "escape vehicle" and 3 man, 14 day logistics (Apollo)

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